Fouling organisms in a mussel cultivation bay: their effect on nutrient uptake and release

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ABSTRACT

LeBlanc, A. R., T. Landry, G. Miron. 2002. Fouling organisms in a mussel cultivation bay: their effect on nutrient uptake and release. Can. Tech. Rep. Fish. Aquat. Sci. 2431: vii + 16 p.

Fouling organisms are causing concerns among mussel growers in Prince Edward Island, Canada. Most of these foulers are sedentary filter feeders, and are therefore potential competitors with mussels for resources. This competition could translate into a reduction of meat yields in mussels. An experiment was carried out to measure the relative effect of fouling organisms on the uptake and release of nutrients. Chlorophyll *a*, ammonia, suspended particulate matter and oxygen concentration were measured in relation to various treatments (presence or absence of foulers). This preliminary study showed that foulers had only a small effect on nutrient use and release. Foulers accounted for about one tenth of chlorophyll *a* consumption by mussels and foulers together. They also contributed about one tenth of the ammonium released by the mussels/foulers unit. There was no significant use of suspended particulate matter by the mussels or the foulers. Moreover, the use of oxygen was not significantly different between mussels and the mussels/foulers unit. Therefore, this study suggests that foulers are not important competitors to mussels.

RESUME

LeBlanc, A. R., T. Landry, G. Miron. 2002. Fouling organisms in a mussel cultivation bay: their effect on nutrient uptake and release. Can. Tech. Rep. Fish. Aquat. Sci. 2431: vii + 16 p.

L'épifaune retrouvée sur les boudins de moules inquiète les aquaculteurs de l'Île-du-Prince-Édouard, Canada. La plupart des espèces constituant cette épifaune sont des filtreurs et peuvent agir comme des compétiteurs aux moules pour plusieurs types de ressources. Cette compétition peut, par exemple, être responsable, de la diminution du rendement en chair chez la moule. Une étude a été réalisée en laboratoire afin de mesurer l'effet de la présence de l'épifaune sur la consommation de nourriture et la libération de nutriments par les moules. La chlorophylle *a*, l'ammonium, la matière organique en suspension et la concentration d'oxygène ont été mesurés sous différents traitements (absence ou présence d'épifaune). Cette étude préliminaire démontre que l'épifaune a un effet minime sur la consommation d'algues et la libération de nutriments par les moules. L'épifaune a contribué à seulement un dixième de la consommation de chlorophylle *a* utilisée par le complexe moules/épifaune. L'épifaune a également libéré environ un dixième de l'ammonium libéré par le système moules/épifaune. Il n'y avait aucune utilisation significative de la matière organique en suspension par les moules ou l'épifaune. Aucune différence significative ne fut observée au niveau de la consommation d'oxygène entre les moules et le complexe moules/épifaune. De manière générale, notre étude suggère que l'épifaune n'est pas un compétiteur important pour les moules.

INTRODUCTION

Biofouling is a major concern for aquaculture operations. Most fouling organisms are sedentary filter feeders (Arakawa, 1990; Lesser et al., 1992; Lodeiros and Himmelmann, 1996; Taylor et al., 1997; Mazouni et al., 1998a, b; Cayer et al., 1999; McNair and Smith, 1999; Uribe and Etchpare, 1999) settling on culture structures or directly on bivalves competing for food and space. The presence of foulers also increases the weight of culture units. Therefore, more work and more equipment is needed to regulate the buoyancy and floatability of these units, as they are not usually resting on the sea bottom.

For species grown in nets or cages, such as scallops and oysters, the settlement of fouling organisms can greatly restrict water circulation. Consequently, less food is available to individuals and growth is decreased (Claereboudt et al., 1994; Lodeiros and Himmelman, 1996; Taylor et al., 1997). In the case of mussels, foulers do not seem to have an effect on growth (Beristain and Taylor, 1998). Because mussels are cultured on long lines, foulers tend to settle directly on shells and water circulation may be less affected. Nevertheless, the increased weight on the shells may restrict the opening of the valves and affect feeding (Lesser et al., 1992; Lodeiros and Himmelman, 1996).

Foulers have to be taken into account when considering the carrying capacity of a system (Mazouni et al., 1998). Because most foulers are filter feeders, their presence may on the one hand increase phytoplankton depletion within aquaculture farms. The increased in consumption rate may in turn result in increased biodeposits and metabolic waste (e.g., ammonia, phosphate) (Mazouni et al., 1998a, b). The increase of certain

nutrients may stimulate phytoplankton production, thereby increasing the food available to aquaculture units. Thus, foulers may have a negative or positive influence on carrying capacity.

The aim of this study was to evaluate the relative uptake and release of nutrients by mussels and related biofoulers found on PEI culture during the ice-free period. More specifically, we tested the hypothesis that the consumption of chlorophyll a or the excretion of ammonia will increase when foulers are present. We also examined whether the presence of foulers increases the use of oxygen or seston. Preliminary results presented here provide a general framework for future investigations on the impact of the fouling community in bivalve aquaculture sites.

MATERIAL AND METHODS

Three mussel socks were collected from Tracadie Bay, PEI before the establishment of ice, in December 2000. Experiments and measurements were carried out at the Ellerslie Hatchery in Ellerslie, PEI. Two 20 cm-long sections were randomly selected from each sock. One section was placed directly in a mesh bag with intact mussels and foulers thus creating a mussels/foulers unit. Mussels from the other section were separated from each other and biofoulers were removed by hand. Mussels and foulers were placed in separate mesh bags. Each mesh bag was then placed in individual 12-L flow-through containers. These containers were supplied with sand-filtered seawater from the Bideford Estuary (Ellerslie, PEI). The seawater was warmed to room temperature (15^{o}C) in holding tubs before being distributed to each container. Three

containers with no animals were used as controls. Water flow was set at about 300 ml/min.

One-liter water samples were taken as soon as animals were added to the containers. Samples were taken every hour during a 12-hour experiment. Subsamples of 250 ml were taken from each 1-L sample and filtered onto Whatman GF/F 25-mm filters. These filters were put in 90% acetone and frozen for later chlorophyll *a* analysis (mg/m^3). Chlorophyll *a* was measured a Turner Design fluorometer (Parsons et al. 1984). Complementary 250-ml subsamples were filtered on pre-ashed and pre-weighed Whatman GF/C 47-mm filters for suspended solids analysis (mg/L). Filters were frozen and later dried at 70°C for 24 hours, weighed then combusted at 500°C for 24 hours and reweighed. Subsamples of 500 ml were frozen and ammonia concentrations were later determined (µg-N/L) using a phenol method described in Parsons et al. (1984).

Water circulation was stopped after 12 hours. Containers were closed and dissolved oxygen (mg/L) was measured with a YSI oxymeter every 15 minutes for one hour. Animals were then taken out and frozen for organic and inorganic matter content determination (g). Water was filtered for the collection of faeces which were then dried, weighed, ashed and reweighed to determine inorganic and organic content (g).

Nutrient concentrations in control containers were considered as the input concentrations. Consumption was calculated by subtracting the output nutrient concentration of the treatment containers from the mean input nutrient concentration (control containers) at a corresponding time. A positive answer indicated an uptake of the nutrient by the animals while a negative one indicated a release of nutrient.

Statistical analyses for total, inorganic and organic seston, chlorophyll *a*, and ammonia consumption and release were carried out using Kruskal-Wallis analyses with time and treatment (control, foulers, mussels, mussels/foulers unit) as the independent variables. A 2-factor ANOVA analysis was used for oxygen consumption per gram of dry weight (log x+1 transformed) with time and treatment as the independent variables. A one factor ANOVA was used to compare means in the organic content of faeces in regard to treatments (independent variable). A nonparametric multiple comparison test (Zar, 1997) or a Tukey test was used to determine which samples differed from each other when necessary. All probability levels were fixed at 0.05.

RESULTS

The total dry weight, total ash weight and the total ash-free weight for all samples are shown in Table 1. Biofouling community weight was low compared to mussel weight (Table 1), corresponding to about 1% of the total ash-free dry weight of the mussel/foulers unit. The fouling community mainly constituted of mussel spat and a few polychaetes.

Results of the statistical analyses are shown in Table 2. Treatments had a significant effect on the uptake of chlorophyll *a* and the release of ammonia. Multiple comparison tests for both cases indicated that mussels and the mussels/foulers unit had the highest values of algal intake and waste excretion (Figs. 1 and 2). Foulers also showed a significant uptake of chlorophyll *a* and release of ammonia (Table 2, Figs. 1 and 2). The foulers consumed only one tenth of the chlorophyll *a* consumed by mussels

and mussels/foulers units. They excreted about one fifth of the ammonia compared to the mussels and one tenth compared to the mussels/foulers units. There was no significant interaction between time and treatment. Time had no effect on the uptake of chlorophyll *a* and the release of ammonia (Table2). For this reason, figures 1 and 2 represent means of all data regardless of time.

Both treatment and time affected organic seston (Table 2). The mussels and mussels/foulers units showed a significant uptake of organic seston while the foulers indicated a significant release. Treatment had no effect on the use of total and inorganic seston (Table 2). Time, however, had an effect in all cases but the differences between times did not show any particular pattern.

Oxygen consumption (per gram of dry weight) was determined for the mussels and the mussels/foulers units (Fig. 3). There was no significant difference between the treatments ($F=0.001$; $P=0.972$) and no significant interaction ($F=0.350$; $P=0.711$). Time, however, had a significant effect ($F=10.096$; $P=0.003$) on oxygen consumption. The first fifteen minutes were significantly different than the last 30 minutes ($q=0.007$ and $P=0.005$).

For the weight of total, inorganic and organic content of faeces, the treatment had a significant effect ($F=18.23$, $P=0.005$; $F=15.207$, $P=0.007$; $F=28.591$, $P=0.002$, respectively). Neither foulers nor mussels showed a significant difference for total ($P=0.069$) and inorganic ($P = 0.135$) content. However, both were significantly different from the mussels/foulers unit. The weight of organic content was significantly different between the foulers and the two other groups ($P = 0.011$ vs mussels; $P = 0.002$ vs mussels/foulers).

DISCUSSION

Results from this study suggest that the epifaunal community associated with mussel socks is not a significant competitor in late December. This is probably due to the relatively low abundance of foulers found at the time of collection. Recently recruited mussel spat (< 10 mm) was the main fouling species found on these lines. This could indicate that they are the main permanent species as opposed to the seasonal occurrence of other fouling species (Ellis, 2001). However, there was no indication of mussel spat from the previous year (individuals in the 20-30 mm size range). The average size of mussels on the sock, excluding the newly recruited spat from the summer of 2000, was 52.12 ± 7.80. The absence of mussel spat from 1999 on these socks could be due to fouling control measures used by some growers which consists of letting the socks touch the bottom to allow rock crabs (*Cancer irroratus*) to clean these socks. This method is common in PEI.

The filtration rate of smaller mussels is lower than for larger mussels (Riisgård and Randlov, 1981; Thompson and Bayne, 1974). Considering that their biomass is also relatively low, they did not appear to be a significant food competitor and nutrients/biodeposits contributor.

Although oxygen consumption between mussels and the mussels/foulers unit was not significantly different, oxygen consumption for large mussels proved to be significantly different in the first 15 minutes. This could either be due to an arrest in filtration and respiration activity in relation to low food concentration (Thompson and

Bayne 1972; Riisgård and Randlov, 1981; Riisgård, 1991) or low oxygen concentration. Arrest in filtration has been observed in mussels at pure algal concentrations below 26 µg/L (Riisgård and Randlov, 1981). Research on mussel feeding has also shown that there is no feeding activity when seston concentration is below 300 particles/ml (Thompson and Bayne, 1974). Our results did not show significant seston depletion in the water. However, our chlorophyll *a* values clearly showed a feeding activity from the larger mussels. These results suggest that mussels were consuming the live algae only, which represent a small proportion of the particulate organic matter. Our results also showed that the epifauna present on mussel socks does not consume a substantial amount of chlorophyll *a*, or seston, and therefore does not constitute a significant competitor for cultured mussels for the December period. It is difficult to compare these chlorophyll concentrations to the food values found in the literature mainly because chlorophyll *a* may not account for the whole weight of the phytoplankton.

Foulers have more impact on the release of ammonia than on chlorophyll *a* consumption. This may be explained by the presence of polychaetes and other organic matter (silt and faeces) in samples. Polychaetes do not consume chlorophyll *a* but excrete ammonia. Silt and decomposing faeces also contribute to the release of ammonia in the water (Smaal and Zurburg, 1980; Prins and Smaal, 1994).

In general, the excretion of faeces by foulers did not seem to be of great importance. The increased excretion of faeces by the mussels/foulers unit may be due, in part, to the handling of the samples. Separating the mussels and the foulers may have got rid of more sediments and previously excreted faeces than the simple rinsing of all samples.

This study indicates that foulers did not seem to contribute much to food (chlorophyll *a* and seston) depletion at the onset of winter, which may be due to their low abundance. Nevertheless, their presence likely increases the concentration of ammonia in the water. Similar studies should be conducted in the summer months when the fouling community is more abundant and diverse to get a better idea of the impact of fouling organisms on mussels.

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Table 1. Total dry, ash and ash-free weight (g) of mussels and fouling organisms for each replicate.

Sample	n	Dry weight[a] (g)	Ash weight[a] (g)	Ash free weight (g)	Shell weight (g
Mussels only					
1	34	19.37	3.36	16.01	188.47
2	40	22.56	4.66	17.90	219.68
3	38	20.52	3.25	17.27	209.11
Mussel + fouler					
Mussels 1	60	30.22	5.21	25.01	288.89
Mussels 2	43	24.00	4.83	19.17	220.06
Mussels 3	52	36.49	7.69	28.80	280.87
Epifauna 1		0.90	0.71	0.19	
Epifauna 2		0.06	0.05	0.01	
Epifauna 3		0.11	0.02	0.09	
Foulers only					
1		1.58	1.37	0.21	
2		2.23	1.68	0.55	
3		1.76	1.36	0.40	

[a]: Shell weight of fouler is included in the dry and ash weights.

Table 2. Summary of results from various Kruskal-Wallis analyses. Multiple comparisons were carried out using a non parametric test on various dependant variables in relation to treatments (control, foulers, mussels and mussels/foulers) and time. Variables are presented by increasing order of concentrations. Significant differences among variables are underlined.

Source of variation	df	H	P
Chlorophyll *a*			
Treatment	3	111.930	<0.001
Time	11	7.109	0.75<P<0.90
Interaction	33	4.962	>0.999
Ammonia			
Treatment	3	117.588	< 0.001
Time	11	5.524	0.9<P< 0.95
Interaction	33	5.718	>0.999
Total seston			
Treatment	3	2.897	0.25<P<0.5
Time	11	63.135	<0.001
Interaction	33	23.143	0.75<P<0.9
Organic seston			
Treatment	3	8.347	0.025<P<0.05
Time	11	23.606	0.01<P<0.025
Interaction	33	31.729	0.5<P<0.75
Inorganic seston			
Treatment	3	1.092	0.25<P<0.5
Time	11	69.906	<0.001
Interaction	33	29.008	0.5<P<0.75

Multiple comparisons :

Chlorophyll *a*:	control	foulers	mussels	mussels/foulers
Ammonia :	control	foulers	mussels	mussels/foulers
Organic seston:	foulers	control	mussels	mussels/foulers

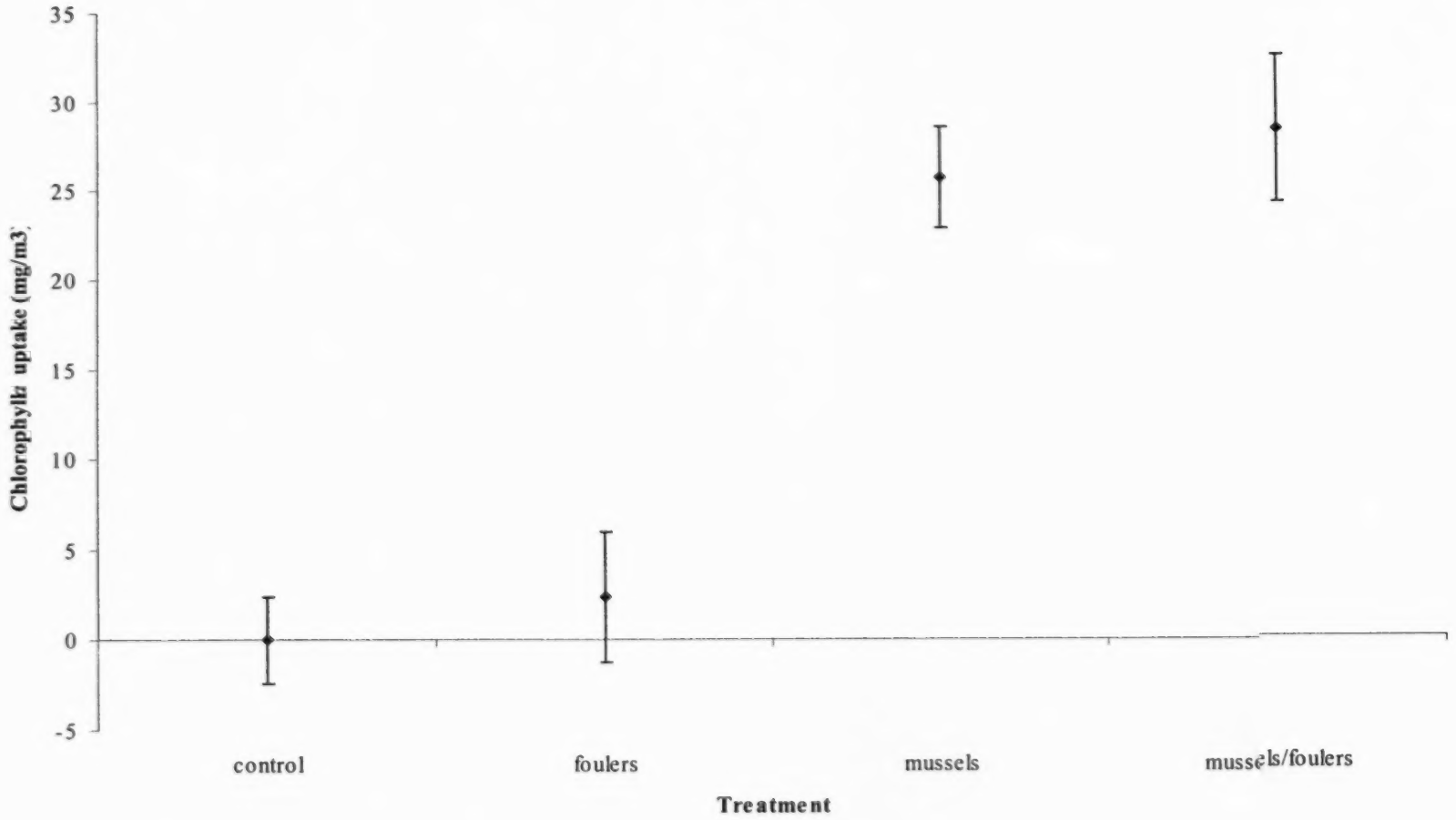

Figure 1. Mean (± SE) consumption of chlorophyll *a* (mg/m^3) from control and treatment containers. Positive values indicate chlorophyll *a* uptake and negative values indicate chorophyll *a* production.

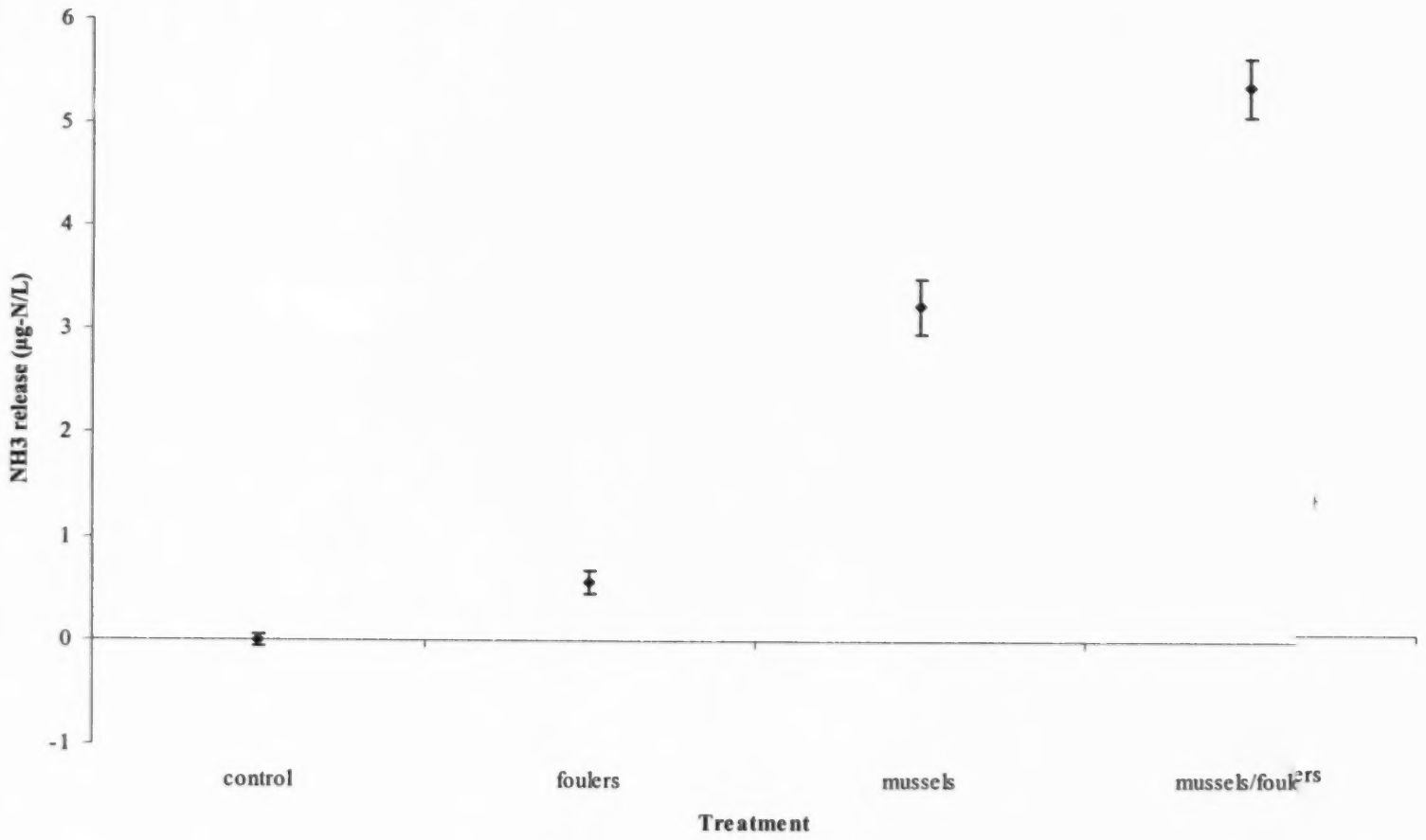

Figure 2. Mean (± SE) release of ammonia (µg-N/L) from control and treatment containers.Positive values indicate ammonia release and negative values indicate ammnia uptake.

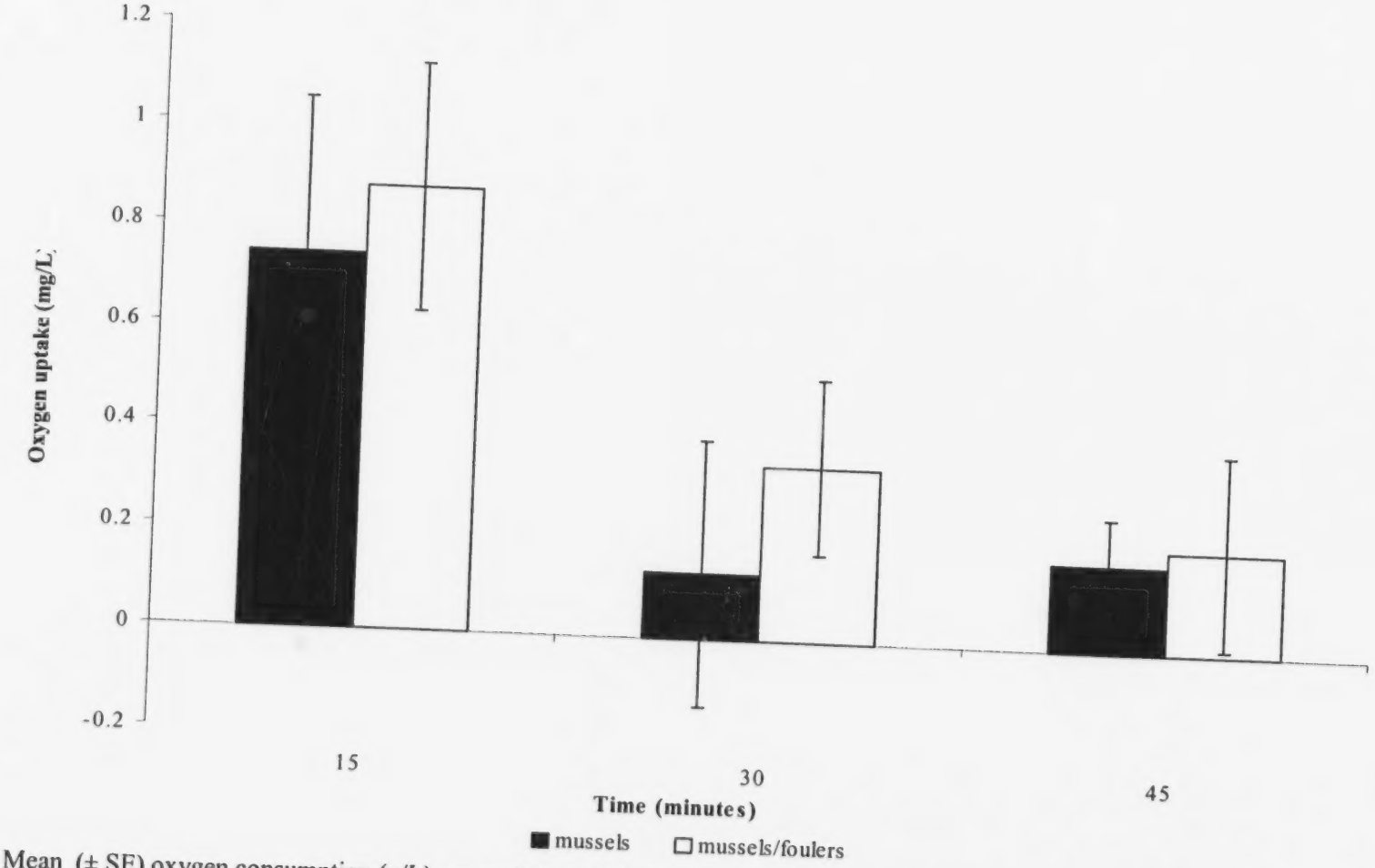

Figure 3. Mean (± SE) oxygen consumption (g/L) per g of dry weight for mussels and mussels/foulers treatments. Positive values indicate oxygen consumption and negative values indicate oxygen release.